Rhode Island Stormwater Design and Installations Standards Manual

Public Workshop

Required Management Volume Calculations and Redevelopment Considerations

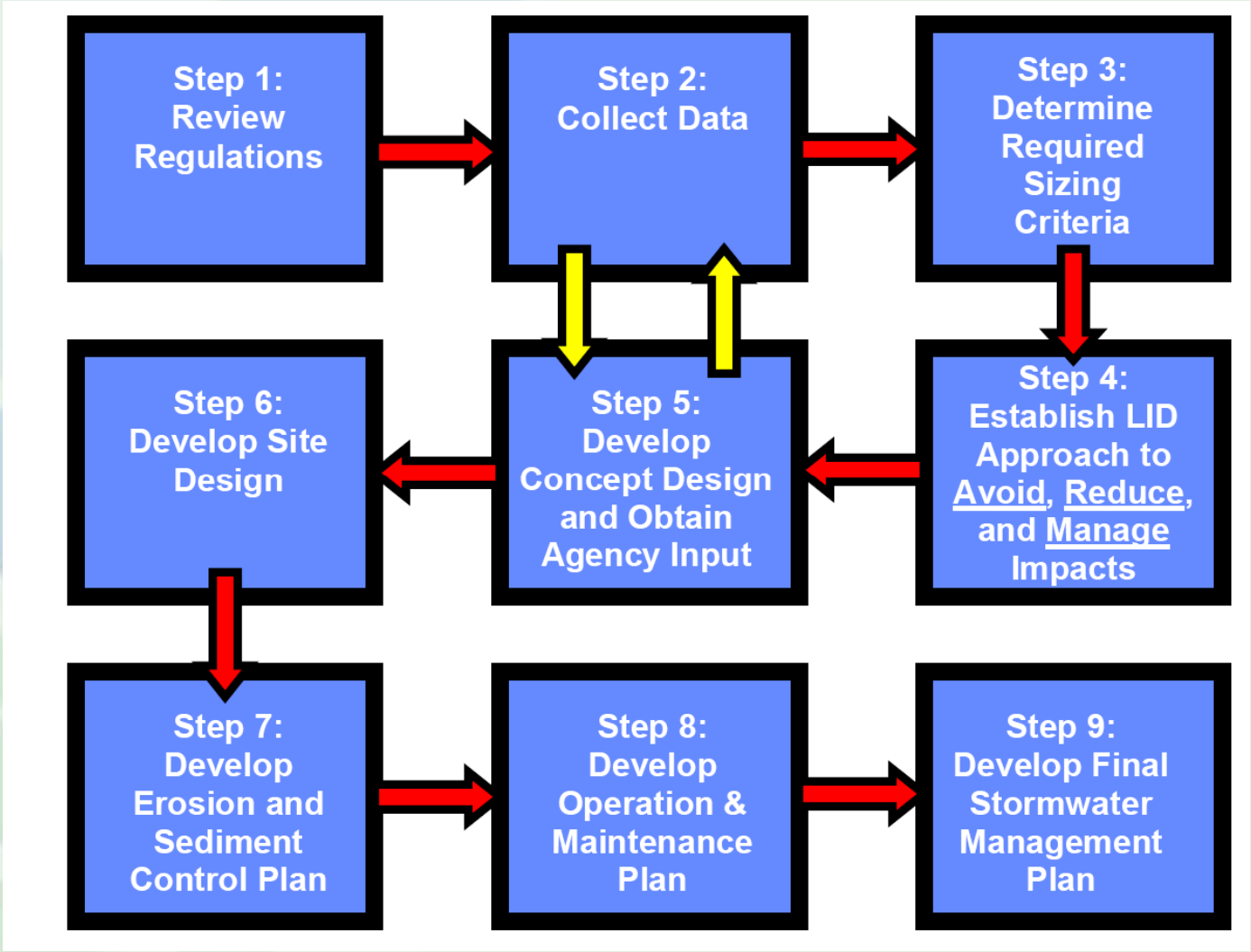
March 22, 2011

Horsley Witten Group, Inc.

Presentation Outline

- Recap of How to Use the Manual
- Required Management Volume Calculations
  - Recharge, Re
  - Water Quality Volume, WQv
    - Minimum WQv
    - WQf vs. WQv and Flow Splitting
    - Use of Modified CN
  - Channel Protection Volume, CPv
  - Overbank Flood Protection, Qp
- Redevelopment Considerations
- Sample Calcs

Steps to Designing an Approvable Stormwater System



Step 3

- What volume requirements must be met? (Re_v, WQ_v, CP_v, Q_p)

These requirements will help determine what type of BMPs are needed at a site

Recharge Criteria, Rev

Requires that the following volume of stormwater be recharged:

$$Re_v = (1") (F) (I) / 12$$

where: Re_v = recharge volume (in acre-feet)

I = impervious area in acres

HSG	Recharge Factor (F)
A	0.60
B	0.35
C	0.25
D	0.10

Recharge Volume

- Considered as part of WQ_v
- Can be achieved by
  - Disconnection of impervious areas (LID Credit)
  - Structural Practice (Table 3-5)
  - Combination of the two
- Should be provided in each applicable drainage area where imp. cover is proposed.
- Must verify that recharge volume actually reaches BMP.
- Recharged roof runoff can be subtracted from WQv but not from Cp_v and Q_p unless drywells sized properly.
- Exemptions: runoff from LUHPPLs, for some extreme physical site limitations.

Water Quality Criteria, WQ_v

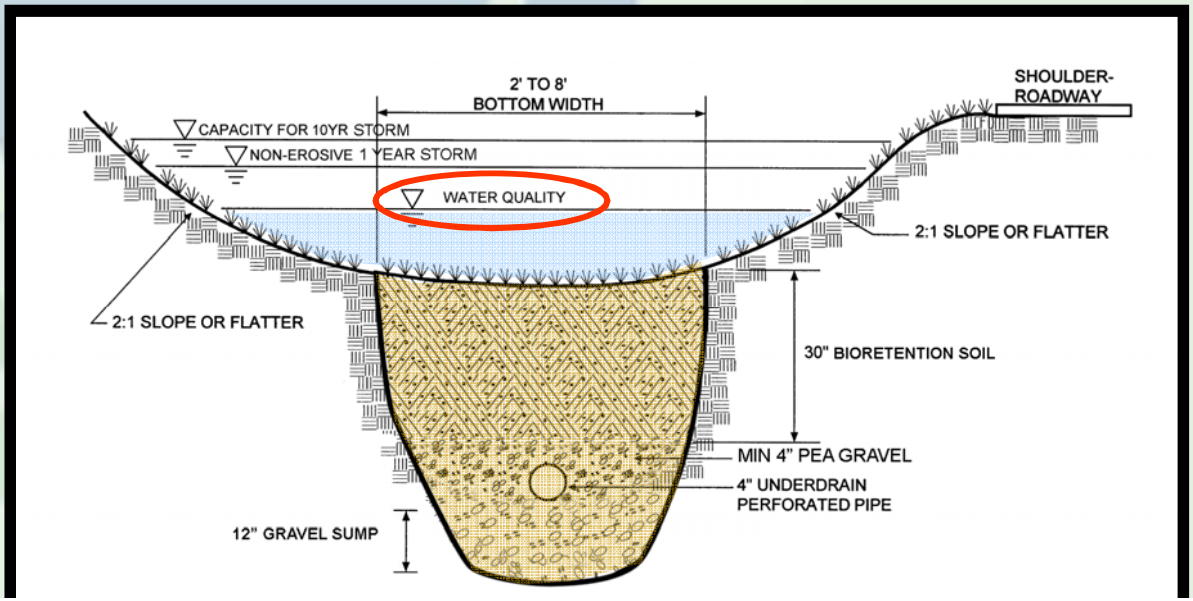
The WQ_v is calculated using the following equation:

$$\underline{WQv = (1") (I) / 12}$$

where:
WQv = water quality volume (in acre-feet)
I = impervious area in acres

Water Quality Volume

- Can be achieved by:
  - Disconnection of impervious areas (LID Credit)
  - Structural Practice (Table 3-6)
  - Combination of the two
- Imp. cover measured from site plan (for entire site);
- Only on-site treatment is required – but off-site flow must be accounted for if draining to a BMP



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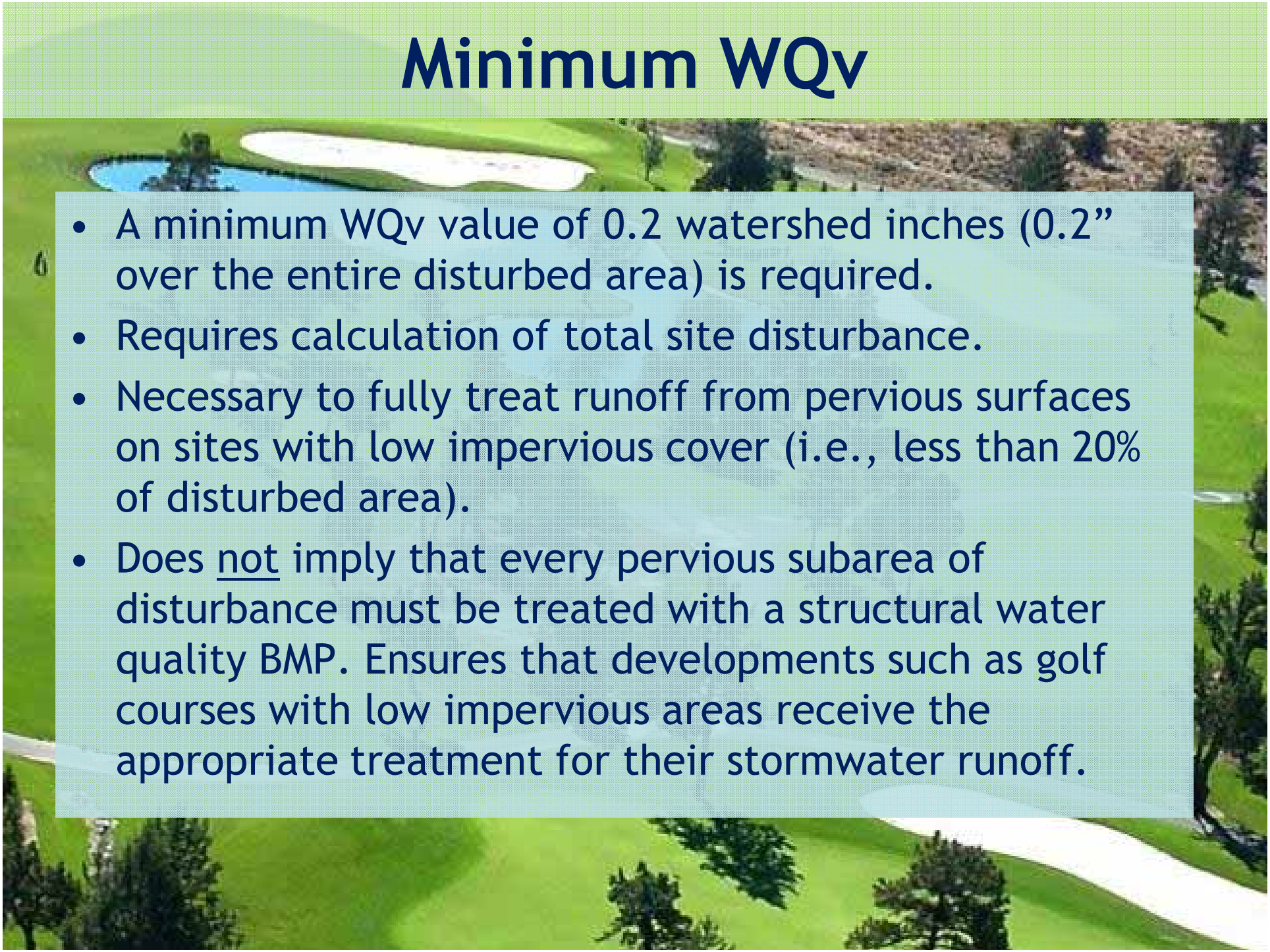
Minimum WQv



- A minimum WQv value of 0.2 watershed inches (0.2” over the entire disturbed area) is required.
- Requires calculation of total site disturbance.
- Necessary to fully treat runoff from pervious surfaces on sites with low impervious cover (i.e., less than 20% of disturbed area).
- Does not imply that every pervious subarea of disturbance must be treated with a structural water quality BMP. Ensures that developments such as golf courses with low impervious areas receive the appropriate treatment for their stormwater runoff.

Min WQv Sample Calculation

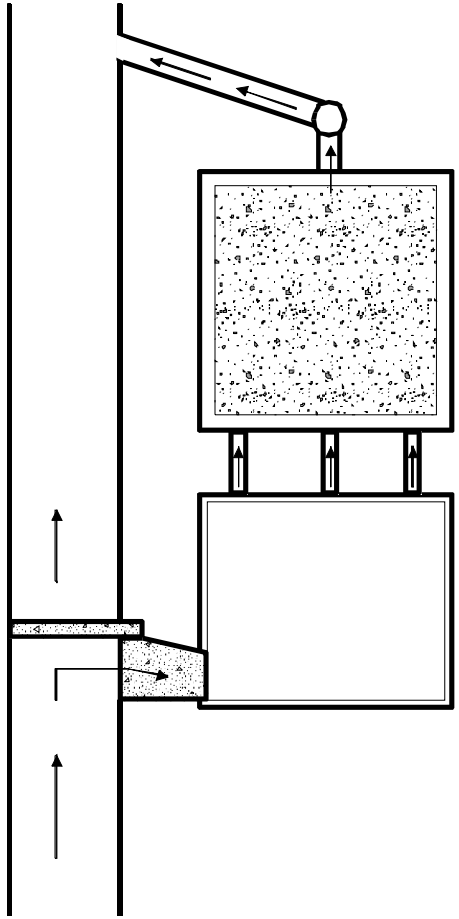
Base Data: I = 4 acres; disturbed area = 10 acres

- WQ_v = (1.0")(I)/12 = 1.0" (4.0 ac)/12 = **0.33 ac-ft (14,375 ft^3)**
- Check WQ_v > minimum req'd 0.2" for disturbed area (10 acres);
- WQ_v min = 0.2"(10 ac)/12 = 0.17 ac-ft; which is less than the computed value, so use 0.33 ac-ft.

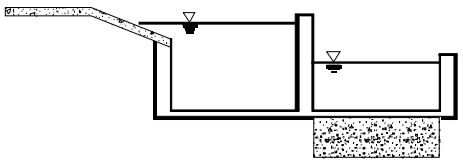
Offline vs. Online Designs

WQ treatment practices can be either on or off-line.

- On-line facilities are generally sized to receive, but not necessarily treat, larger storms.
- Off-line facilities are designed to receive a certain flow rate through a weir, channel, manhole “flow splitter”, etc.

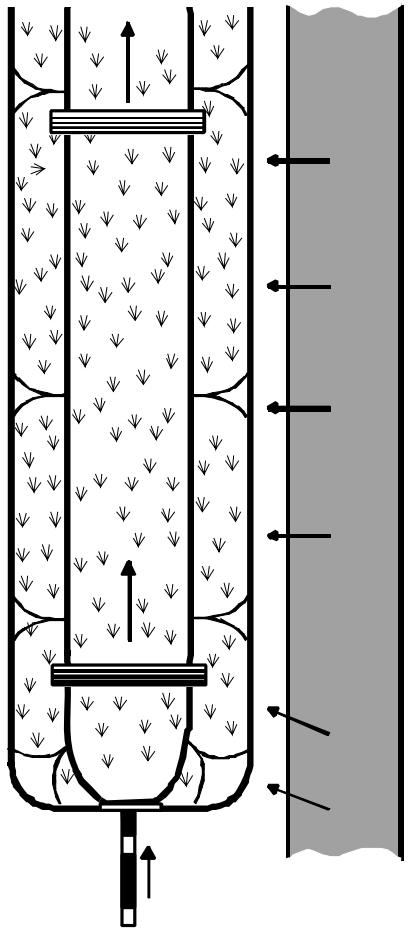


PLAN VIEW



SECTION

OFF-LINE



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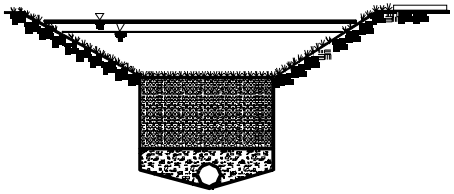

SECTION

ON-LINE


On-Line


NOT
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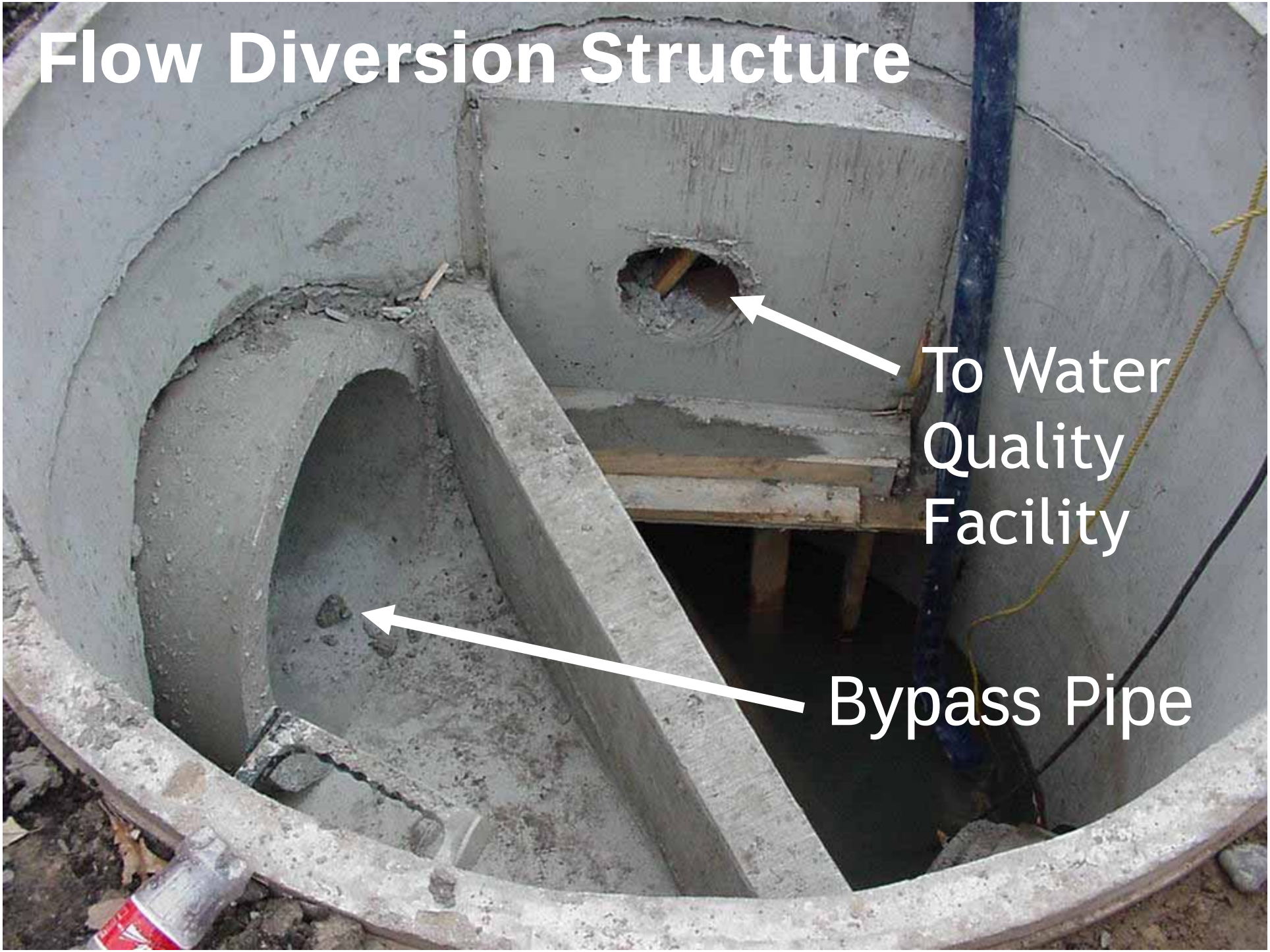
On-Line

Flow Diversion Structure

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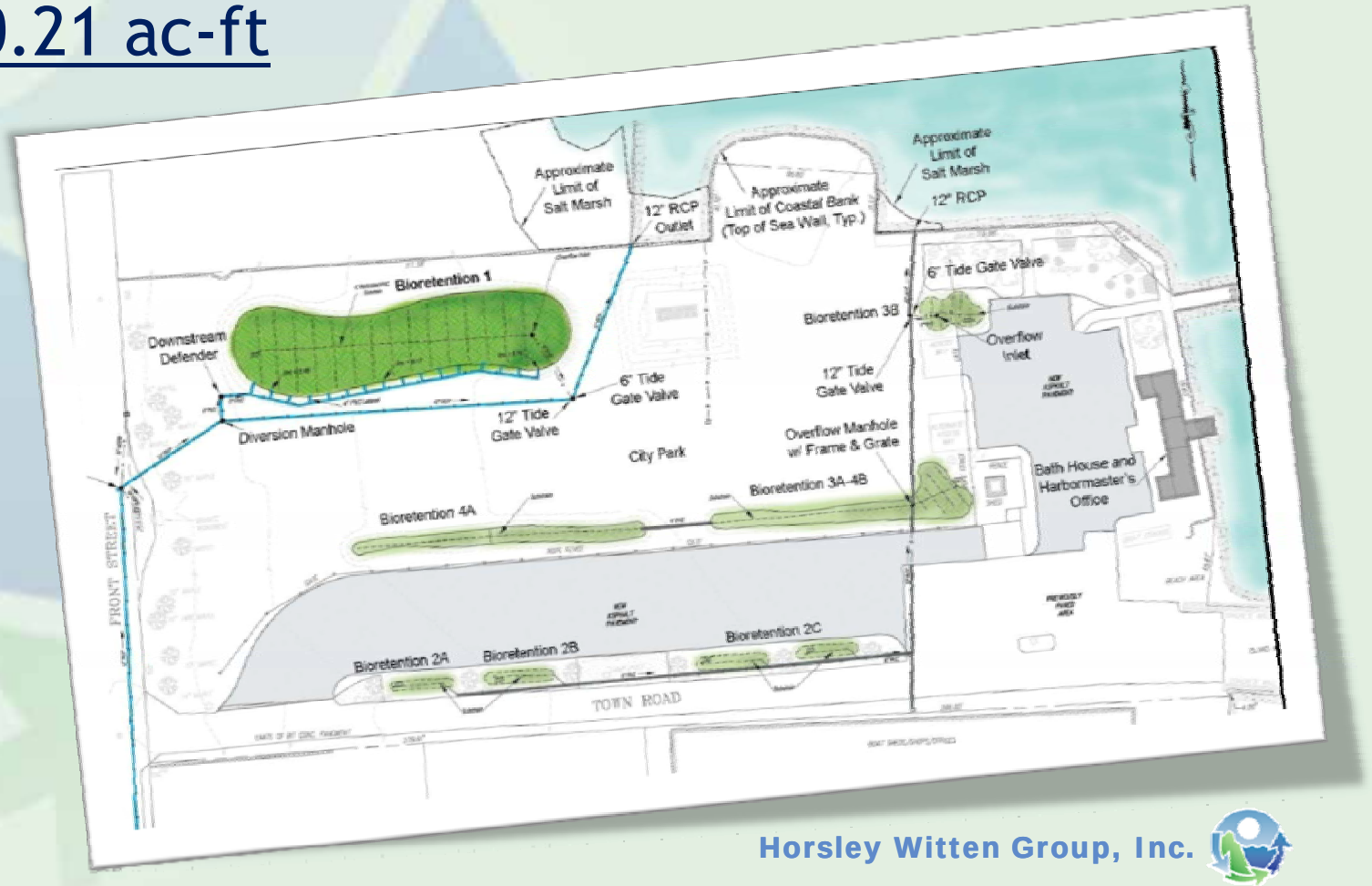
WQ_f vs. WQ_v

- Standard 3 is volume-based. Why would a corresponding WQ flow be necessary?
  - To ensure that the full WQ_v reaches an off-line BMP
  - Some proprietary devices are flow-based
- A Modified Curve Number (CN) is needed:
  - Traditional TR-55 CNs can lead to significantly underestimated runoff from small storm events
  - Used to calculate WQ_f
  - Used to correctly model the WQ event

Design Example #2, App. D

- Impervious area (I) = 2.5 acres;
- WQ_v = (1.0")(I)/12 = 1.0" (2.5 ac)/12
- WQv = 0.21 ac-ft



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Diversion Str.
Off-Line

Section 3.3.3.2 - Water Quality Peak Flow Calculation

Using the WQv, a corresponding modified CN is computed utilizing the following equation:

$$CN = 1000 / [10 + 5P + 10Q - 10(Q^2 + 1.25\ Q*P)^{½}]$$

Where:

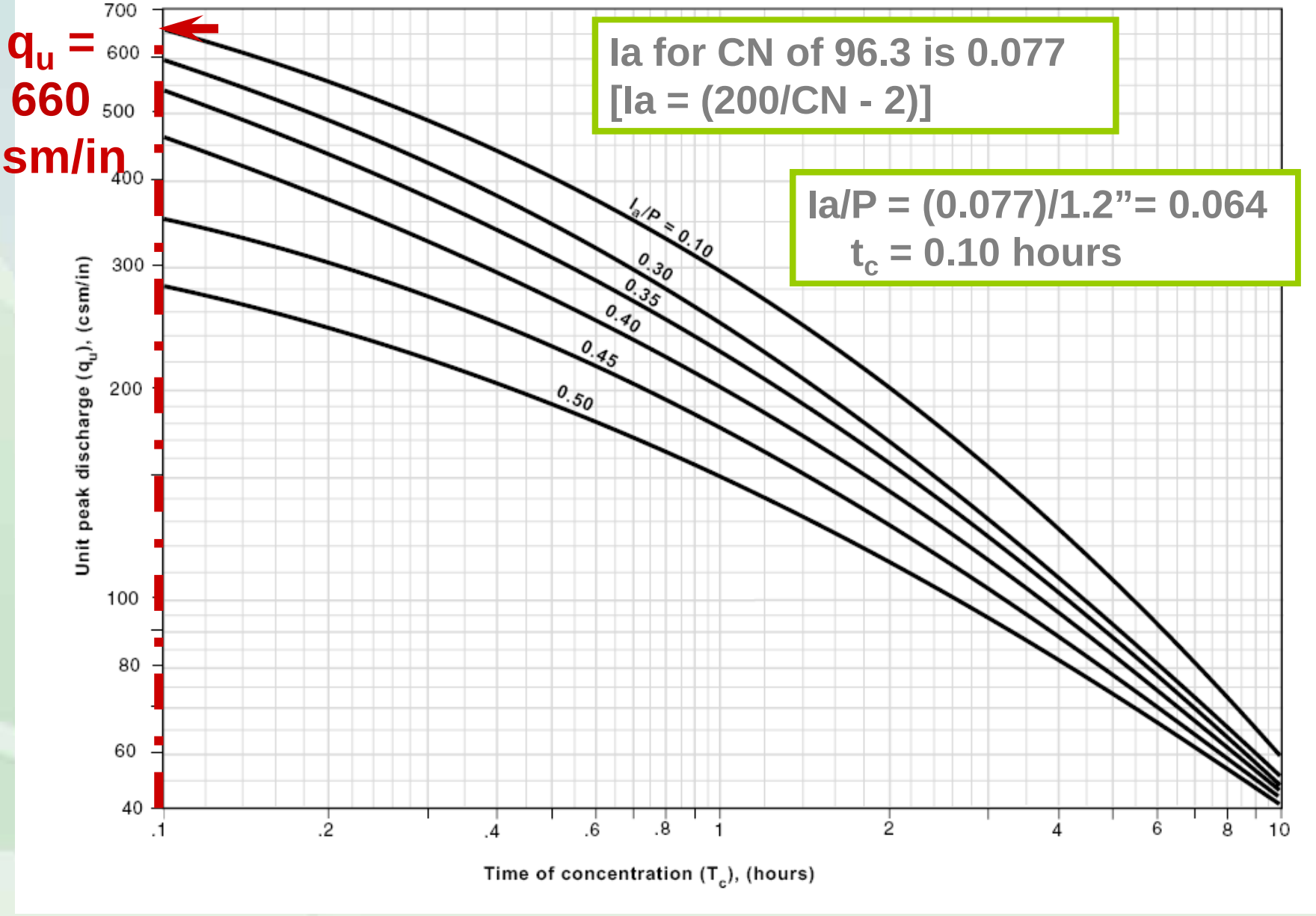
- P = rainfall, in inches (use 1.2 inches)
- Q = runoff volume, in inches (equal to WQv ÷ area)
- Q = (0.21 ac-ft) (12 inches/ft) / (3.0 acres) = 0.84 inches

$$CN = 1000 / [10 + 5(1.2\ in) + 10\ (0.84\ in) - 10((0.84\ in)^2 + 1.25\ (0.84\ in)(1.2\ in))^{½}]$$

$$CN = 1000 / [10 + 6.0 + 8.4 - 14.02] = 96.3$$

**Use this in either H/H model with a 1.2" precip event, or use TR-55 spreadsheet, to find WQ_f

Exhibit 4-III Unit peak discharge (q_u) for NRCS Type III rainfall distribution



Compute Peak Discharge (Q_{peak})

$$Q_{peak} = q_u * A * WQ_v$$

Where:

- Q_{peak} = the peak discharge, in cfs
- q_u = the unit peak discharge, in cfs/mi^2/inch (660 csm/in)
- A = drainage area, in square miles (0.0047 sq miles)
- WQ_v = Water Quality Volume, in watershed inches (0.84 inches)

$$Q_{peak} = 660 * 0.0047 * 0.84 = 2.61 \text{ cfs}$$

**Good rule of thumb is about 1.1 cfs/acre of imp. cover

Use orifice eqtn to size pipe/orifice

$$Q_{peak} = CA(2gh)^{1/2}$$

where:

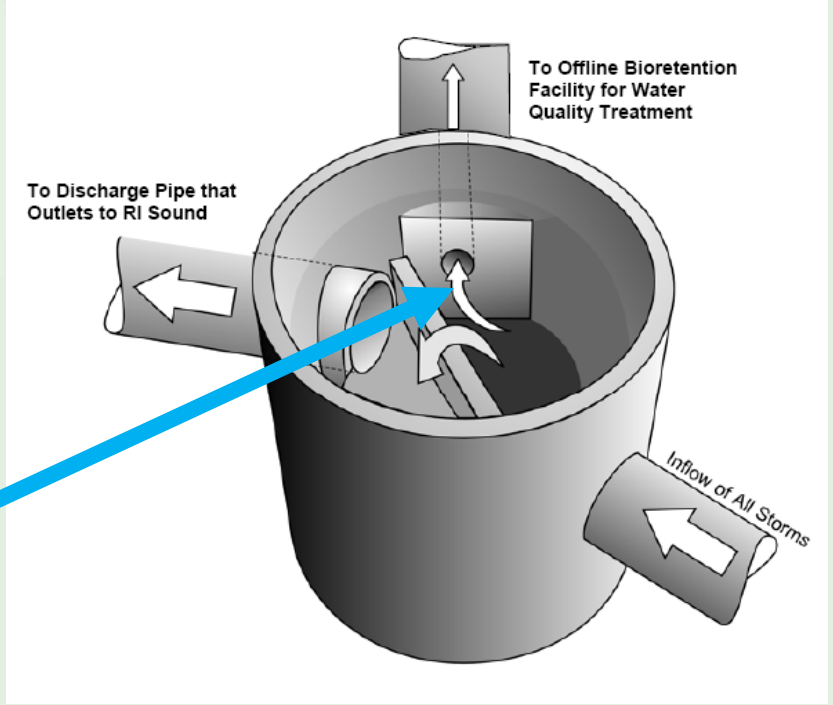
- C = discharge coefficient (0.6)
- A = cross-section area of orifice ($D^2/4*\pi$)
- g = acceleration due to gravity (32.2 ft/s^2)
- h = head, height above center of the orifice (assume 2 ft)

$A = Q_{peak} / [C*(2gh)^{1/2}] = 2.61$ cfs/ $[0.6*(2*32.2ft/s^2 * 2ft)^{1/2}] = 0.38$ ft^2

Diameter = $[(0.38\ ft^2)*4/\pi\ ]^{1/2}$ =
0.7ft (12in/ft) = <u>8.4 in</u>

Use 10-in pipe

(conservative up-sizing)



Channel Protection Criteria, Cp_v

- Channel protection must be supplied by providing 24-hour ED for the one-year 24-hour design storm event.
- CPv computed using methodology in App H.4 or by calculating 65% of the runoff volume from the post-development 1-year, 24-hour Type III storm:

Vs = 0.65 * Vr

  - where Vs = Cp_v; and
  - Vr = runoff volume from 1-year, 24-hour Type III storm.

- CPv released at roughly a uniform rate:

Average release rate = Vr / T

  - where Vr = defined above; and
  - T = extended detention time (24 hours).

Updated Precipitation Values

RI County	24-hour (Type III) Rainfall Amount (inches)						
	1-Year	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Providence	2.7	3.3	4.1	4.9	6.1	7.3	8.7
Newport	2.8	3.3	4.1	4.9	6.1	7.3	8.6
Bristol	2.8	3.3	4.1	4.9	6.1	7.3	8.6
Kent	2.7	3.3	4.1	4.8	6.2	7.3	8.7
Washington	2.8	3.3	4.1	4.9	6.1	7.2	8.5

Hydrologic Basis for Design

- TR-55 or TR-20 (or equiv) used for determining peak discharge;
- Off-site areas modeled as “present condition”;
- Length of overland flow used in t_c limited to 100’ for post-developed conditions;
- Cp_v <u>not required</u> for:
  - discharges to a large river (i.e., 4th-order stream), surface water body > 50 acres (lake, pond reservoirs), estuary, or tidal waters.
  - small sites with impervious cover ≤ 1 acre
  - Sites where peak flow < 2 cfs

Overbank Flood Protection, Q_p

- Downstream overbank flood protection must be provided by controlling the post-development peak discharge rate to the pre-development rate for the 10-year and 100-year, 24-hour design storm events.
- The Q_p criteria can be waived for sites that:
  - Discharge to a large river (i.e., 4th order stream), surface water body > 50 acres (lake, pond reservoirs), estuary, or tidal waters.
  - A downstream analysis indicates that peak discharge control is not necessary.

Hydrologic Basis for Design

- TR-55 or TR-20 used for determining peak discharge;
- Pre-developed conditions for on-site areas will be woods, meadow, or rangeland in “good” condition;
- Off-site areas modeled as “present condition” for storage requirements;
- Where off-site areas drain to a facility, must demonstrate safe passage of 100-year storm based on actual conditions upstream;
- Length of overland flow used in time of concentration limited to 150’ for pre-developed conditions and 100’ for post-developed conditions; and
- Must demonstrate that flows from the 100-yr event will be safely conveyed to a practice.

Redevelopment

- Redevelopment is defined as any construction, alteration, or improvement that disturbs a total of 10,000 square feet or more of existing impervious area where the existing land use is commercial, industrial, institutional, governmental, recreational, or multifamily residential.
- Redevelopment sites with less than 40%* impervious coverage must meet new development criteria, except that it can be met either on-site or at approved off-site location in same watershed, if on-site was explored to MEP.
- For sites ≥ 40%*, only standards 2, 3, and 7-11 must be addressed, on-site or at approved off-site location.

*Jurisdictional wetland areas and conservation easements are subtracted from total site area for this calculation.

Redevelopment ≥ 40% imp. cover

- Reduce existing impervious area by at least 50%; or
- Use LID techniques for at least 50% of area; or
- Use BMPs (Chapt. 3) to provide recharge and water quality management for at least 50% of area; or
- Any combination of impervious area reduction, other LID techniques, or BMPs for at least 50% of area.

*If none of the above are feasible, alternatives may be proposed that achieve an equiv. pollutant reduction (e.g., treating 100% of redev. area by BMPs with lesser pollutant removal efficiency than stipulated in Standard 3).

Infill Development

A development site that meets all of the following:

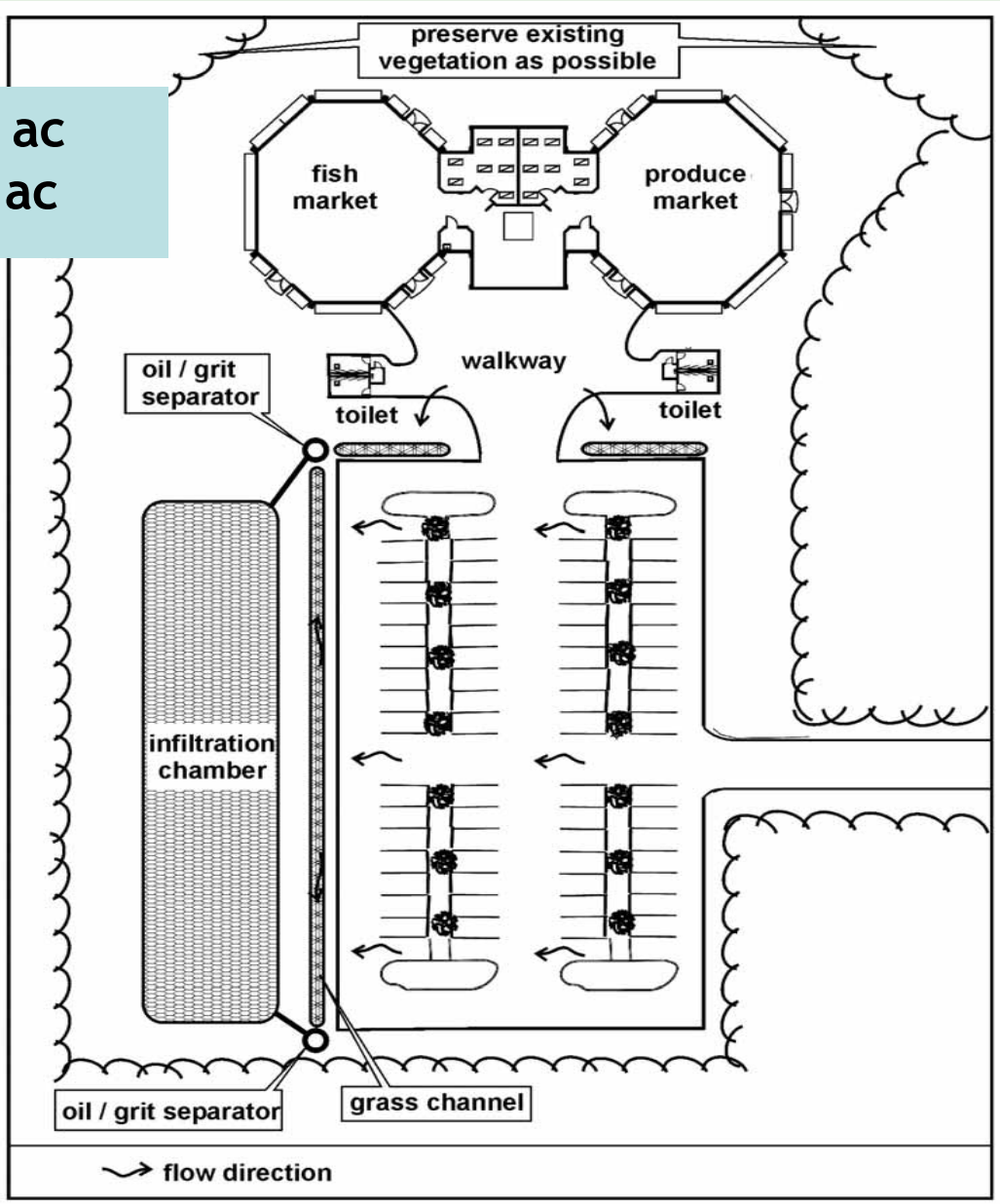
- Predominately pervious (<10,000 sq ft);
- Surrounded by existing development;
- Served by an existing network of infrastructure (no utility line extensions); and
- Site is ≤ 1 acre.

- Existing impervious area may be excluded from the stormwater management plan in most cases.
- Requirements for Stds 2 and 3 and 7-11, either on-site or at approved offsite location within same watershed.
- Must demonstrate compliance with Std 1 to MEP.

Sample Calculations

Total Disturbed Area = 3.0 ac
Impervious Area=1.56 ac

The Sunshine Market is a hypothetical commercial development consisting of a fish and produce market. It is located in Charlestown, RI and discharges to Green Hill Pond. On-site soils are Windsor loamy sand (HSG "A").



Required Volume Calculations

- Compute required Re_v based on A soils and Sect 3.3.2

Re_v = [(1") (F) (I)] / 12
= [(1") (0.6) (1.56 ac)] (1ft/12in)
= 0.08 ac-ft = ~3,500 cf

- Compute WQ_v

WQ_v = [(1") (I)] / 12
= [(1")(1.56 ac)] (1ft/12in)
= 0.13 ac-ft = ~5,700 cf

Min. WQ_v = [(0.2")(DA)] / 12
= [(0.2")(3.0 ac)] (1ft/12in)
= 0.05 ac-ft = ~2,200 cf

- Cp_v and Q_p are **waived** since site discharges to coastal waters with tide effects